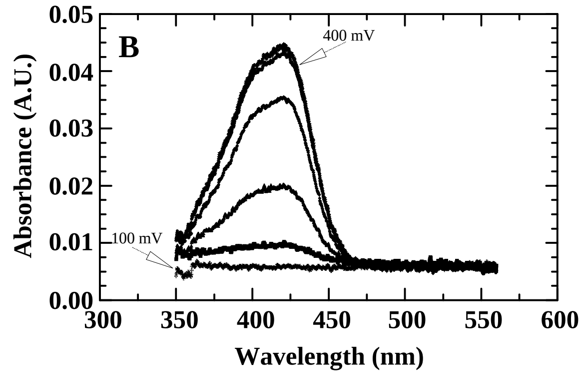
Optically Transparent Diamond Electrodes for Chemical Analysis - J. Zak (Silesian Technical University), J. Stotter, S. Haymond (Michigan State University), J. Butler (Naval Research Laboratory), and G. Swain (Michigan State University)

A new type of optically transparent electrode (OTE) is reported on – an electrically conductive diamond thin film.[1] One property of diamond that has not yet been exploited in electrochemistry or chemical analysis is the optical transparency. High quality (chemically pure and low in defects) diamond has one of the widest optical windows of any material extending from the bandgap absorption edge at 225 nm well out to 12 µm or more in the far-IR.[2] Such diamond is free of allowed electronic states in the bandgap between the valence and conduction band edges and is, in theory, transparent to low energy UV and the entire range of visible light. However, imperfections in diamond, like those that exist in boron-doped polycrystalline films, create electronic and vibrational states within the gap that give rise to multiple absorption and luminescence centers spanning from the UV to the near IR, and reduce the visible light throughput.[2,3]

The free-standing electrode (0.38 mm thick and 8 mm in diameter) was mechanically polished to a 7 nm rms roughness over a 10 µm linear distance, boron-doped (0.05% B/C in the reactant gas mixture), and mounted in a thin-layer transmission cell.

Figure 1 (reproduced from ref. 1) shows a series of spectra recorded for the electrooxidation of 1 mM $Fe(CN)_6^{-4}$ in 1 M KCl at potentials between 100 and 400 mV. The range covers the states of the solution species from the transparent reduced form, which exists at 100 mV, to the absorbing (λ_{max}=420 nm) oxidized form which is completely achieved at 400 mV. Each spectrum was recorded only when two successive spectra were identical. This indicated that equilibrium had been achieved in the cell. Equilibrium was reached in about 10 minutes at each potential. The broad absorbance increases with increasing positive potential up to 400 mV after which no additional increases are seen as the analyte in the cell was completely electrolyzed. The optical absorbance trends were completely reversible if the potential was stepped in the cathodic direction to form the transparent (at 420 nm) ferrocyanide. The spectra were also fully reproducible with multiple cycles demonstrating the stability and usefulness of the diamond OTE in spectroelectrochemistry.



Our long-term goals for this work are to develop OTE's for (i) chemical analysis in the UV-visible region (250-800 nm) and (ii) structure-function studies of redox active proteins and enzymes in the IR region (< 1000 cm^{-1}) of the electromagnetic spectrum. Two types of OTE's will be reported on - a free standing diamond disc and a polycrystalline diamond film deposited on quartz.

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